3. (Twice Amended) A lead-free solder paste including a plurality of different types of metal powder mixed with a flux, the plurality of metal powders including two different Sn alloy powders, each Sn alloy powder including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn, the plurality of metal powders having a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn.

REMARKS

In response to the Official Action mailed on March 26, 2002, the Applicants propose to amend claim 3 to improve its readability. No new matter has been added. Reconsideration of the rejections of the claims is respectfully requested in view of the above proposed amendment and the following remarks.

Examiner Cooke and Examiner Tom Dunn are thanked for their courtesy in granting an interview on April 9, 2002 to discuss the present application. The various issues dealt with during the interview are discussed below under the category to which they relate.

Page 2 of the Official Action of March 26, 2002 indicates that the Examiner did not receive copies of the references which were filed as part of an Information Disclosure Statement on January 25, 2002. Duplicate copies of the references were filed at the Patent and Trademark Office on April 4, 2002 and are hopefully now in the Examiner's possession.

In the Official Action of March 26, 2002, claims 3, 5 - 12,

and 14 - 16 were rejected under 35 USC 112 as indefinite because, according to the Official Action, claim 3 recited two different ranges for the same feature. It was agreed at the interview that claim 3 was not indefinite and that the rejection under 35 USC 112 would be withdrawn. However, it is believed that claim 3 could be made more succinct without affecting its scope, so the Applicants propose to amend claim 3 to eliminate redundant language. Specifically, the language "one of the metal powders being a Sn alloy powder, another of the metal powders being selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder" has been deleted as unnecessary in light of the subsequent recitation in the same claim that the plurality of metal powders include two Sn alloy powders.

Claim 3 has also been amended to clarify that the two Sn alloy powders recited in this claim are two different Sn alloy powders. It was agreed at the interview that changing "two Sn alloy powders" to "two different Sn alloy powders" would make claim 3 easier to read. This change does not affect the scope of claim 3, because the two Sn alloy powders referred to in claim 3 are part of the "plurality of different types of metal powder" recited earlier in the claim. Therefore, the two Sn alloy powders are inherently different from each other, since all of the metal powders in the "plurality of different types of metal powder" are by definition of different types. The changes to claim 3 are thus in all respects stylistic and are unrelated to reasons of patentability. Claim 3 remains identical in scope to

its form as originally filed.

Claims 1 - 2, 17, and 18 were rejected under 35 USC 102(b) as anticipated by Paruchuri et al (U.S. Patent No. 5,928,404, referred to below as Paruchuri). This rejection is respectfully traversed.

Claim 1 describes a lead-free solder paste including a plurality of metal powders having a composition when melted including less than 3 mass % Cu. Paruchuri does not disclose or suggest such a composition.

Paruchuri states in column 3, line 64 that Cu represents **3 - 10%** of the total metal weight of its solder paste, and in the Examples of Paruchuri, all of the pastes have a Cu content of 5.5 wt % or above. Expressed in mass percent, the Cu content in Paruchuri would be 3 - 10 mass percent. There is no contemplation in Paruchuri of lowering the Cu content to below 3 mass percent, as set forth in claim 1.

Page 3 of the Official Action notes that the amounts of the components in Paruchuri are expressed in weight percent, and the Official Action states that the amounts of these components would be different if converted to mass percent (which are the units employed in the claims of the present application). In fact, the percentage of a component is identical whether expressed in weight percent or mass percent. The weight percent of a specific component in a composition is the weight of the component per unit weight of the composition. The mass percent of a specific component in a composition is the mass of the component per unit mass of the composition. Since weight is equal to mass

multiplied by the acceleration due to gravity (g), weight percent = weight of component/unit weight of composition = (mass of component x g)/(unit mass of composition x g), and since g in the numerator cancels out g in the denominator, the equation for weight percent simplifies to weight percent = mass of component/unit mass of composition, which is equal to the mass percent. Thus, if the Cu content in Paruchuri is converted from weight percent to mass percent, it will still be 3 - 10%, and therefore outside of the range specified in claim 1. Accordingly, it is impossible for Paruchuri to anticipate claim 1 or claims 2 and 17 which depend from claim 1.

Claim 18 describes a method of soldering including heating a solder paste including a plurality of different types of metal powder to melt the metal powders. Paruchuri does not disclose or suggest such a method. As described in column 3, line 34 of Paruchuri, the additive powder used in that reference does not melt except for a certain amount of dissolution during the soldering process. Again, column 5, lines 53 - 59 state that in the examples, soldering is carried out in an oven with a thermal profile such that a primary powder 2 melts but the additive powder 4 does not melt (except for a certain amount of dissolution). This statement applies not to a single composition but to all 20 compositions shown in Table 1. The claims of Paruchuri include cases in which the additive powder is bismuth, lead, or tin, and in each case, the claim specifies that the additive powder does not melt, further emphasizing that Paruchuri does not contemplate melting of the additive powder 4. On the

contrary, in Paruchuri it is essential for the additive powder not to melt in order for the resulting solder joint to exhibit the desired effects of a large stand-off height and fatigue resistance (referred to in column 3, lines 36 - 40 of Paruchuri), because if the additive powder melts, it will not function as a reinforcing material. Thus, Paruchuri is unequivocal that in soldering using its soldering composition, the additive powder is not to be melted.

Page 4 of the Official Action states that if the powder being claimed in the present application melts during soldering, the powder of Paruchuri would also melt "because they appear to be the same powder and would thus have the same properties". This statement is incorrect, because it disregards the process conditions under which soldering takes place. Whether a powder melts during soldering depends not only on the composition of the powder, but also on the soldering temperature and the length of time for which the powder is exposed to the soldering temperature. For a given primary powder and additive powder of Paruchuri, a person skilled in the art could select soldering conditions (heating time and temperature) aimed at melting the primary powder without melting the additive powder (the result desired by Paruchuri), or a person skilled in the art could select soldering conditions aimed at melting both the primary powder and the additive powder (which is the opposite of the result desired by Paruchuri), even though the primary powder and the additive powder are unchanged. Thus, the composition of the primary and additive powders is not by itself determinative of

whether the additive powder melts. Paruchuri clearly states that the additive powder does not melt during its soldering method (column 3, line 34), and that statement applies for all of the different powder compositions which it discloses. This means that Paruchuri carries out soldering under conditions in which the additive powder does not melt. Thus, Paruchuri clearly lacks the step recited in claim 18 of "heating the solder paste to melt the plurality of metal powders" in the paste. As such, Paruchuri cannot anticipate this claim. Claim 18 is thus allowable.

Claims 3 - 16 were rejected under 35 USC 103(a) as unpatentable over Paruchuri. This rejection is respectfully traversed.

Claim 3 describes a lead-free solder paste including a plurality of different types of metal powder mixed with a flux, with the plurality of metal powders including two different Sn alloy powders. Paruchuri does not disclose or suggest such a solder paste. Paruchuri discloses a solder composition including a primary powder in the form of an Sn alloy and an additive powder in the form of an elemental metal, such as elemental Ag, Cu, Ni, or Bi. There is no contemplation in Paruchuri of a solder paste containing more than one Sn alloy powder. This is clear from Table 1 in column 5 of Paruchuri, in which all of the Examples employ an elemental metal powder as the additive powder.

The bottom of page 6 of the Official Action describes claim 3 as claiming a product by process. It was agreed at the interview that neither claim 3 nor any of the other product claims describes a product by process, so it is believed that all

of the arguments in the Official Action which were premised on the product claims being product by process clams have been overcome.

Accordingly, since Paruchuri does not disclose or suggest a solder paste including two different Sn alloy powders as set forth in claim 3, it cannot render this claim obvious. Claim 3 and claims 4 - 12 and 14 - 16 which depend from it are thus allowable.

Claim 13, which depends from claim 1, states that the plurality of metal powders of the solder paste of claim 1 have a composition when melted containing at most 1.0 mass % of Cu. There is no disclosure or suggestion in Paruchuri of such a solder paste. As stated above with respect to claim 1, Paruchuri sets a lower limit of 3 weight % (= 3 mass %) on the Cu content in its solder. There is no suggestion in Paruchuri of a Cu content of less than 3 weight % (= 3 mass %) as in claim 1 or a Cu content of at most 1 weight % (= 1 mass %) as in dependent claim 13.

As discussed on page 8 of the specification of the present application, the Cu content is restricted in the present invention to prevent the melting point of the solder paste from becoming too high and allowing thermal damage to electronic components or printed circuit boards at the time of reflow soldering. According to page 8, line 22 of the specification, the Cu content is preferably at most 1.0 mass %. There is no mention in Paruchuri of any harmful effects resulting from the high Cu content which it employs, and so no suggestion of

employing a lower Cu content than the range of 3 - 10 weight % which Paruchuri specifies.

Page 7 of the Official Action states with respect to claim 13 (and also claim 15) that it would have been obvious to modify the Cu content of Paruchuri by reduce it to lower the melting point of the solder. The Applicants respectfully disagree. In Paruchuri, Cu is added as an additive powder, and as discussed above, soldering is carried out in Paruchuri without melting the additive powder, so the Cu does not alloy with the other metal components of the solder and thus does not affect the melting point of the solder. In addition, Paruchuri expresses no desire to or advantage from lowering the melting point. Furthermore, since Paruchuri states in column 3, line 64 that including 3 - 10 weight % of Cu provides a solder which has improved fatigue and creep resistance, it can be assumed that adding a smaller amount of Cu will not produce the desired effects sought by Paruchuri. For all these reasons, a person skilled in the art could find no motivation the Official Action to modify Paruchuri as proposed in the Official Action.

Therefore, as Paruchuri does not disclose or suggest the Cu content set forth in claim 13, it cannot render this claim obvious. Claim 13 is thus allowable.

Claims 1 - 18 were rejected under 35 USC 103(a) as unpatentable over Anderson et al (US Patent No. 5,527,628, referred to below as Anderson '628). This rejection is respectfully traversed.

Independent claims 1 and 3 each describe a solder paste

including a plurality of different types of metal powder mixed with a flux, and independent claim 18 describes a method of soldering comprising applying to a substrate a solder paste including a plurality of different types of metal powder mixed with a flux. There is no disclosure or suggestion anywhere in Anderson '628 of a solder paste including a plurality of different types of metal powder mixed with a flux.

Anderson '628 discloses a ternary eutectic Sn-Ag-Cu solder. Column 5, line 62 of that patent states that the solder can be in the form of a solder powder, but there is no mention whatsoever of a paste including a plurality of different types of metal powder. It is clear that when the solder of Anderson '628 is in the form of a powder, it is in the form of a single type of powder. For example, column 6, line 23 of Anderson '628 states that HPGA solder powder can be made from a prealloyed ingot, which necessarily results in a single type of powder.

Thus, as Anderson '628 itself does not disclose or suggest a solder paste including a plurality of different types of metal powder, and as the Official Action has not shown any teachings in the art which could be combined with Anderson '628 to result in a solder paste including a plurality of different types of metal powder, the Official Action fails to show teachings of all the features of independent claims 1, 3, 18, so Anderson '628 cannot render these claims obvious. Independent claim 1, claims 2, 13 and 17 which depend from claim 1, independent claim 3, claims 4 - 12, 14 - 16 which depend from claim 3, and independent claim 18 are therefore allowable.

Page 8 of the Official Action states that a solder paste containing the solder composition of Anderson '628 is a substantially similar product as the product being claimed in the present claims. The Applicants respectfully submit that the product of the present claims is completely different from the product described by Anderson '628. The product claims of the present application are not directed to a solder alloy per se, but to a solder paste. This solder paste has features which are missing from and not suggested by Anderson '628, e.g., a plurality of different types of metals powder mixed with a flux.

As described on page 6 of the present application, the use of a mixture of different type of metal powders prolongs the time required for the metal powders to completely melt during reflow soldering at a given reflow temperature. The prolonged melting time prevents the formation of voids in soldered portions, even at a low reflow temperature, and the occurrence of tombstoning is prevented. Table 1 of the present application also demonstrates that a solder paste comprising a plurality of solder powders behaves quite differently from a solder paste having the identical chemical composition but containing only a single powder. Comparative Examples 1 and 2 in Table 1, which contained only a single powder, had a much higher occurrence of voids, a much higher occurrence of tombstoning, and poorer printability than examples of the present invention which contained a plurality of different types of metals powder. These are significant advantages nowhere suggested by Anderson '628.

In light of the foregoing remarks, it is believed that the

present application is in condition for allowance. The proposed claim amendment is directed only to stylistic changes which were agreed upon at the interview as improving its readability, so it raises no new issues. The proposed claim amendment could not be made earlier because it is responsive to suggestions first made at the interview after the most recent Official Action. Entry of the proposed amendment is therefore proper.

Respectfully submitted,

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ATTACHMENT A

Marked-up version of the amended claims:

3. (Twice Amended) A lead-free solder paste including a plurality of different types of metal powder mixed with a flux, [one of the metal powders being a Sn alloy powder, another of the metal powders being selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder, wherein] the plurality of metal powders [include] <u>including</u> two <u>different</u> Sn alloy powders, each Sn alloy powder including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn, the plurality of metal powders having a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn.